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THE VASCULAR RESPONSE OF THE KIDNEY IN IN ACUTE URANIUM NEPHRITIS—THE INFLUENCE OF THE VASCULAR RESPONSE ON DIURESIS[1]

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INTRODUCTION AND REVIEW OF PREVIOUS EXPERIMENTS

The following investigation, which has primarily as its object a study of the vascular response of the kidney in acute uranium nephritis, serves as the concluding number of two other papers which have appeared in this journal (1 and 2).

The previous articles have been concerned with the effect of different diuretics in acute uranium nephritis and with the part played by the anesthetic employed in the experiments in determining the efficiency of the nephritic kidney.

In the experiments which have been referred to, there was constantly associated with the development of an anuria, or with a condition approaching anuria, histological evidence

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of severe tubular injury. There was not, however, any constant or marked histological evidence of vascular injury.

The response of the renal vessels to various types of stimuli in these anuric and practically anuric animals was apparently sufficient to induce a flow of urine; yet in this group of experiments the animals remained anuric.

It seemed, therefore, advisable to determine, if possible, whether the epithelial involvement of the kidney was the primary cause for the development of the anuric state, or whether associated with the degenerative changes in the epithelium, the vascular mechanism of the kidney even though it showed no evidence of histological changes of a degenerative character, had become functionally incompetent. This incompetency, if it does exist, could be best determined not by comparing the vascular response of a nephritic animal with a normal animal, but by comparing the vascular response of animals nephritic from the same quantity of the nephrotoxic substance which following an anesthetic may either become anuric or remain diuretic.

The experiments which form the basis for this communication have been conducted on the same general plan as were the experiments of Schlayer (3) and his associates, and of the more recent experiments of Pearce, Hill and Eisenbrey (4). An early acknowledgment of my indebtedness to these investigators is therefore eminently proper.

The observation was first made by Pearce (4) that certain animals nephritic from potassium dichromate, uranium nitrate or corrosive sublimate following an anesthetic became anuric. It was also observed by Pearce that in certain animals nephritic from uranium and anuric following an anesthetic, the kidney vessels were responsive to such peripheral stimuli as adrenalin, hypertonic sodium chloride solution and caffein.

The phenomenon of vasodilation with little or no diuresis was considered by Pearce to be due to an impermeability of the glomerulus which follows the anesthetic.

As a result of the previously mentioned observations (1

and 2) which have been made concerning the relation which exists between the degree of epithelial damage and the efficiency of the nephritic kidney, the following experiments have been undertaken in the hope of ascertaining which element of the kidney, vascular or epithelial, is most concerned in the establishment of an anuria.

The following investigation is, therefore, concerned with the group of animals nephritic from uranium which following an anesthetic become anuric (Group II) and also with other animals that will serve as control experiments (Groups I and III) which are nephritic from the same quantity of uranium yet following an anesthetic do not become anuric.

A study of the vascular response of the kidney, the influence of the vascular response on diuresis, and the pathology of the kidney in these anuric and diuretic animals will furnish the material for this investigation.

DISCUSSION OF THE TECHNIQUE EMPLOYED IN THE EXPERIMENTS

In conducting the experiments two types of anesthetics have been employed: Gréhant's anesthetic and morphine-ether.

Depending upon the type of anesthetic used in the experi-

TABLE 1

Group I. Control experiments—Gréhant's anesthetic. The vascular response of the kidney in animals remaining diuretic, following Gréhant's anesthetic

NUMBER OF EXPERIMENT	URINE DAY OF EXPERIMENT	NORMAL RATE OF URINE FLOW PER MINUTE	VASCULAR RESPONSE OF KIDNEY FROM CAFFEIN	EFFECT OF CAFFEIN ON URINE FLOW	VASCULAR RESPONSE OF KIDNEY FROM ADRENALIN	EFFECT OF ADRENALIN ON URINE FLOW
1	475	7	+88	12	—68	4
2	580	2	+89	5	—30	5
3	634	5	+32	8	—72	1
4	375	6	+47	8	—62	2
5	547	3	+46	6	—76	0
6	708	0	+32	12	No record	0
		0	+81	0	—48	0

TABLE 2

Group II. The vascular response of the kidney in animals anuric, following Gréhant's anesthetic

NUMBER OF EXPERIMENT	URINE DAY OF EXPERIMENT	NORMAL RATE OF URINE FLOW PER MINUTE	VASCULAR RESPONSE OF KIDNEY FROM CAFFEIN	EFFECT OF CAFFEIN ON URINE FLOW	VASCULAR RESPONSE OF KIDNEY FROM ADRENALIN	EFFECT OF ADRENALIN ON URINE FLOW
1	580	0	+66	0	—42	0
2	1018	0	+17	0	—16	0
3	777	0	+40	0	—20	0
4	650	0	+63	0	—72	0
5	1531	0	+71	0	—40	0
6	115	0	+93	0	—58	0
7	685	0	+65	0	—68	0

ments and also depending upon the age of the animal, the animals used in these experiments fall into three groups.

Group I (table 1) represents those animals which following Gréhant's anesthetic have remained diuretic. Group II (table 2) represents those animals which following the same amount of Gréhant's anesthetic per kilogram have become anuric, while Group III (table 3) represents all the

TABLE 3

Group III. Control experiments—Morphine-ether anesthesia. The vasular response of the kidney in animals diuretic, following morphine-ether

NUMBER OF EXPERIMENT	URINE DAY OF EXPERIMENT	NORMAL RATE OF URINE FLOW PER MINUTE	VASCULAR RESPONSE OF KIDNEY FROM CAFFEIN	EFFECT OF CAFFEIN ON URINE FLOW	VASCULAR RESPONSE OF KIDNEY FROM ADRENALIN	EFFECT OF ADRENALIN ON URINE FLOW
1	747	4	+71	10	—33	6
2	697	9	+38	18	—60	6
3	645	8	+55	12	—21	4
4	582	4	+39	7	—51	2
5	455	1	+37	5	Rupt're of rubber b'g in oncometer	0
6	359	1	+87	1	—18	0

animals in the series which receive morphine-ether. All of the animals of the last group were diuretic at the beginning of the experiment. During the course of the experiments two of the animals became anuric.

All of the animals employed in the experiments were given subcutaneously 6.7 mgm. of uranium nitrate on two successive days. At the end of forty-eight hours following the initial injection of uranium the animals were anesthetized and employed for physiological study.

In these experiments the percentage of glucose in the urine and apparently the severity of the albuminuria were largely dependent upon the age of the animal. The changes in the urine from uranium and the influence of the age of the animal in determining the severity of these changes have been discussed in a previous publication (2).

During the course of the experiments the changes in general blood pressure were obtained from a canula in the carotid artery. The blood pressure changes and the changes in the heart volume were recorded simultaneously by an ordinary mercury manometer and a Hürthle manometer.

The changes in kidney volume were determined by using the following method: The left kidney was constantly employed for the observations. It is more accessible than the right kidney and, therefore, necessitates less handling during its arrangement in the oncometer. The kidney was not decapsulated. Without the fat being dissected away from around the renal vessels the kidney was placed in a copper oncometer. Within the oncometer the kidney rested on and was surrounded by a thin rubber bag filled with water. Leading from the rubber bag was a rubber tube which could either be connected with a piston recorder, that indicated the changes in kidney volume along with the blood pressure changes on the kymograph tracing, or it could be connected with a water manometer whereby the changes in kidney volume could be indicated in millimeters of water. Both of these methods were employed with each animal.

The changes in kidney volume when the piston recorder

was used were obtained in millimeters by measuring the rise or fall in the lever from the normal point that it had previously indicated on the tracing. These changes in volume will be indicated by the use of + and — signs.

During each experiment one observation was made on the effect on urine flow of an exaggerated constriction of the renal vessels, by inducing the constriction while the kidney volume was increasing from the use of caffein which had induced a dilatation of the kidney vessels. With this exception, after the use of any substance which altered the volume of the kidney, time was allowed for the lever of the piston recorder to regain its normal point. This was determined by measuring the distance between the lever and the base line.

The substances which were employed to test the response of the renal vessels were caffein for its peripheral dilator effect, and adrenalin for its peripheral constrictor effect. The caffein was employed in the dose of 1cc. per kilogram or a 1 per cent solution, while adrenalin was used in the dose of 1 minim of the 1—1000 solution. (Parke, Davis and Company). Two cc. of the adrenalin solution which was used was equivalent to 1 minim of the 1-1000 solution.

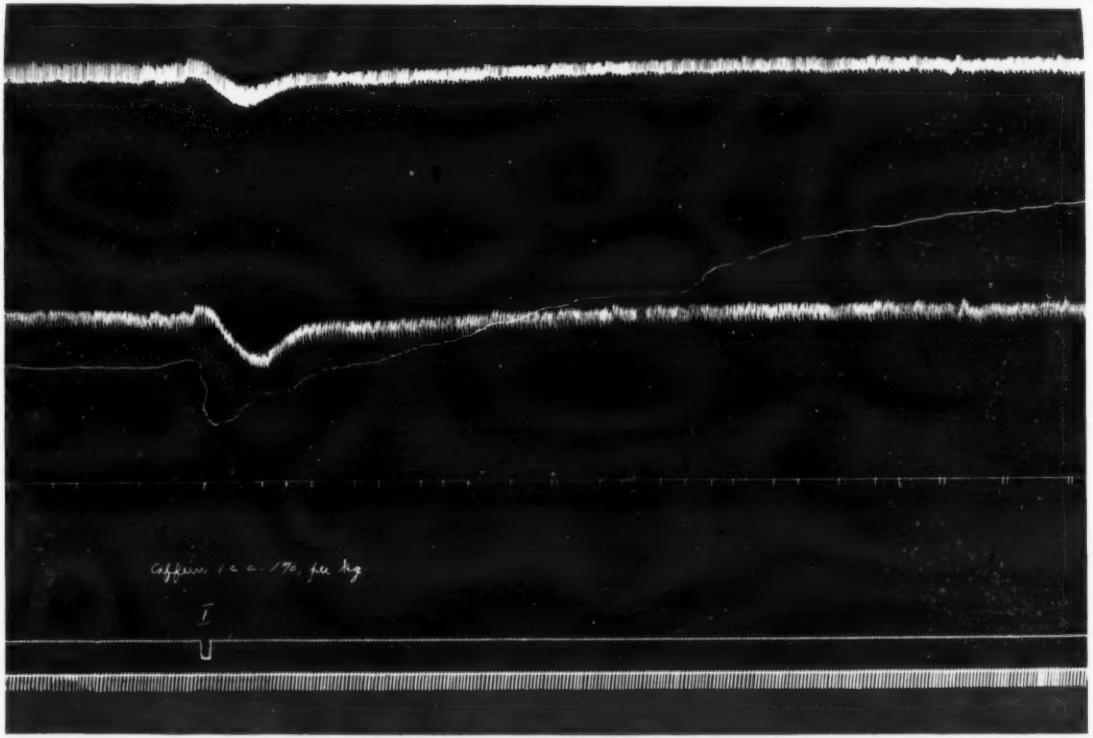
The caffein and adrenalin solutions were given to the animals intravenously, the femoral vein being employed for the purpose.

A canula was placed in the right ureter and the flow of urine recorded in the usual way on the tracing.

THE VASCULAR RESPONSE OF THE KIDNEY IN ACUTE URANIUM NEPHRITIS

The vascular response of the kidney nephritic from uranium has been studied in nineteen animals. Thirteen of the animals have been anesthetized by Gréhant's anesthetic in 60 per cent strength, while the remaining six animals have received morphine ether.

As a result of the effect on kidney function of the nephrotoxic substance plus the effect of the anesthetic there are three groups of animals in which the response of the kidney



TRACING 1, EXPERIMENT 3, TABLE 1

The figure represents from above downward the tracing from the Hurthle manometer, carotid blood pressure, kidney volume, signal magnet and time marker. The animal remained diuretic following Gréhant's anesthetic. Associated with the vasodilation of the kidney vessels from caffein there was an increase in urine flow.

vessels and the influence of this response on diuresis, should be studied.

Group I (table 1) includes those animals which following Gréhant's anesthetic have remained diuretic.

Group II (table 2) includes those animals which following Gréhant's anesthetic have become anuric, while Group III (table 3) represents those animals which following morphine-ether have remained diuretic.

As will be seen by referring to the different tables which are to follow, there are animals in Group I and in Group III which are diuretic at the beginning of the experiment, but later developed an anuria. The explanation for the gradual development of an anuria which is illustrated by these animals will be considered in the general discussion of the experiments.

All of the animals in the different groups received the same quantity of uranium nitrate per kilogram. The study of the vascular response of the kidney was commenced in each experiment forty-eight hours after the initial uranium injection. The duration of the action of the nephrotoxic substance was, therefore, the same in all of the experiments.

All of the animals of the different groups were diuretic on the day of the experiment.

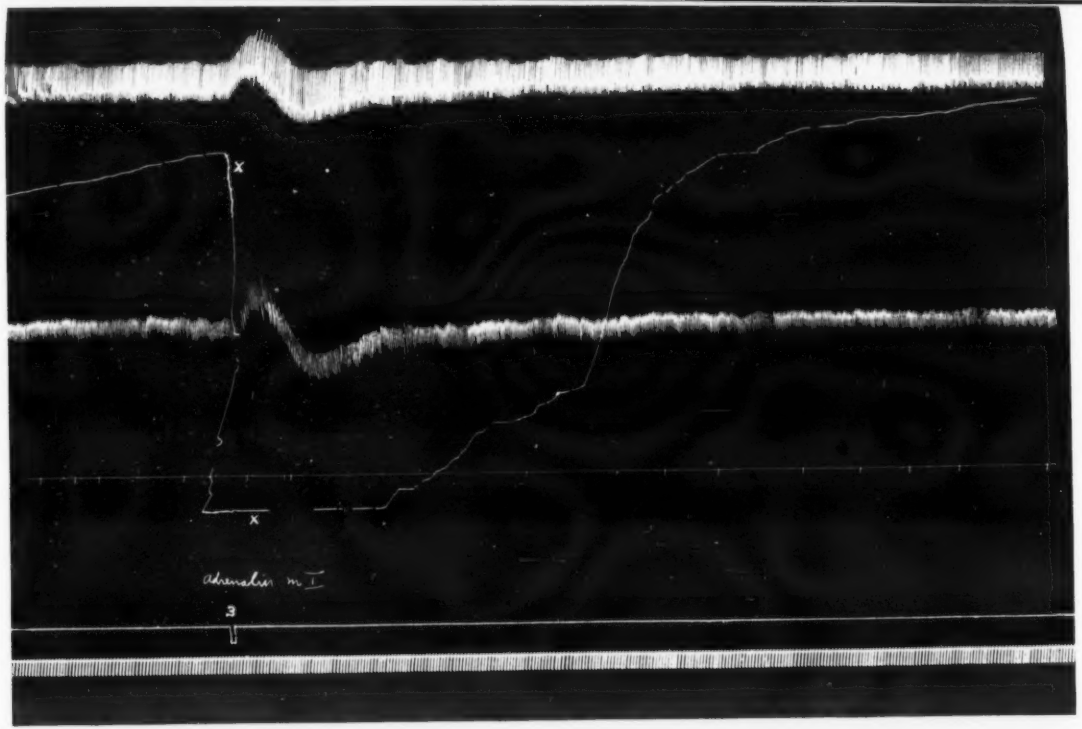
Group I. Control Experiments

Gréhant's anesthetic. The animals in this group were either young adult animals or puppies varying in age from four to seven and one-half months.

Following Gréhant's anesthetic in 60 per cent strength all of the animals with one exception remained diuretic. The animal which served as the exception became actively diuretic caffein (experiment 6, table 1).

The members of this group have shown a vascular response from caffein which varied between a minimum vasodilation of +32 mm. to a maximum vasodilation of +89 mm. (tracing 1, table 1).

In all of the experiments, with one exception, following



TRACING 2

The tracing is from the same animal as tracing 1. Adrenalin was given at the height of the caffein vasodilation to ascertain the effect of an exaggerated vasoconstriction on urine flow. With the marked vasoconstriction from adrenalin the flow of urine was decreased. With the vasodilation which followed the adrenalin constriction the flow of urine increased. At the points on the tracing indicated by x, the lever of the piston recorder was readjusted to the drum.

a vasodilation from caffein there was an increase in the flow of urine.

The degree to which the flow of urine is increased is apparently not dependent upon the degree of vasodilation (experiment 6, table 1) serves especially well to illustrate this point. Early in the experiment a vasodilation of +32 mm. increased the flow of urine twelve drops per minutes, while later in the experiment a vasodilation of +81 mm. had no effect in establishing a urine flow.

In this group of diuretic animals (Group I) a decrease in the flow of urine has resulted from the vasoconstrictor effect of adrenalin when this action was sufficiently pronounced (tracing 2).

The degree of vasoconstriction has varied between a minimum of —30 mm. to a maximum of —76 mm. A decrease in kidney volume of —68 mm. reduced the flow of urine eight drops per minute, a decrease of —72 mm. seven drops per minutes, while a vasoconstriction of —30 mm. failed to affect the flow of urine. The flow remained constant—five drops per minute both before and after the constrictor effect from adrenalin.

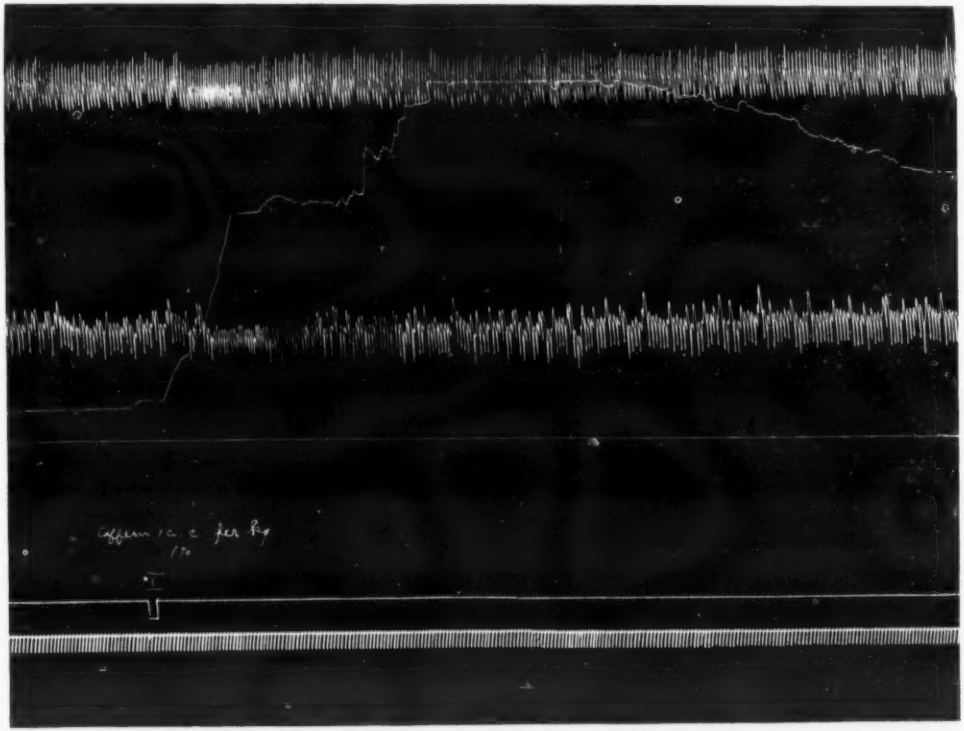
Group III. Control Experiments

Morphine-ether anesthesia. The animals of this group were either puppies or full-grown dogs. All of the animals were deeply anesthetized. Following the anesthetic all of the animals remained diuretic.

The effect of caffein and of adrenalin in this group of animals was very similar to the effect obtained in the previously described group of control animals in which Gréhant's anesthetic was employed.

The effect of caffein was to induce a vasodilation of the renal vessels accompanied by an increase in kidney volume varying between the limits of +37 to +87 mm. (tracing 5, table 3).

Following the vasodilation there was with one exception an increase in the flow of urine. Again in this group of experiments it will be seen that the degree of vasodilation is ap-



TRACING 3. EXPERIMENT 1, TABLE 2

The tracing is from an animal anuric following Gréhant's anesthetic. The tracing shows the renal vessels to be responsive to caffein. The vasodilation had no effect in establishing a flow of urine.

parently not the sole factor which determines the degree of diuresis. In experiment 6, for instance, a vasodilation increasing the kidney volume +87 mm. does not increase the flow of urine. The flows of urine was one drop per minute both before and after the injection of caffein. In experiment 2, however, with a rise in kidney volume of only +38 mm. the output of urine per minute was doubled; the urine flow increasing from 9-18 drops per minute.

When adrenalin was employed in the animals of this group it invariably induced a vasoconstriction of the renal vessels and a decrease in kidney volume (tracing 6).

The degree of vasoconstriction varied from a minimum response of —18 mm. to a maximum response of —60 mm. The effect of the vasoconstriction was either to reduce the flow of urine or to cause a temporary stoppage of urine flow. The most marked effect from adrenalin in reducing the flow of urine occurred in the experiments in which the maximum constrictor effect from adrenalin was obtained (experiment 2, table 3).

In this experiment a fall in kidney volume of —60 mm. was obtained from adrenalin, and the flow of urine was reduced from 18 drops per minute to 6 drops per minute.

Group II. Anuric Animals

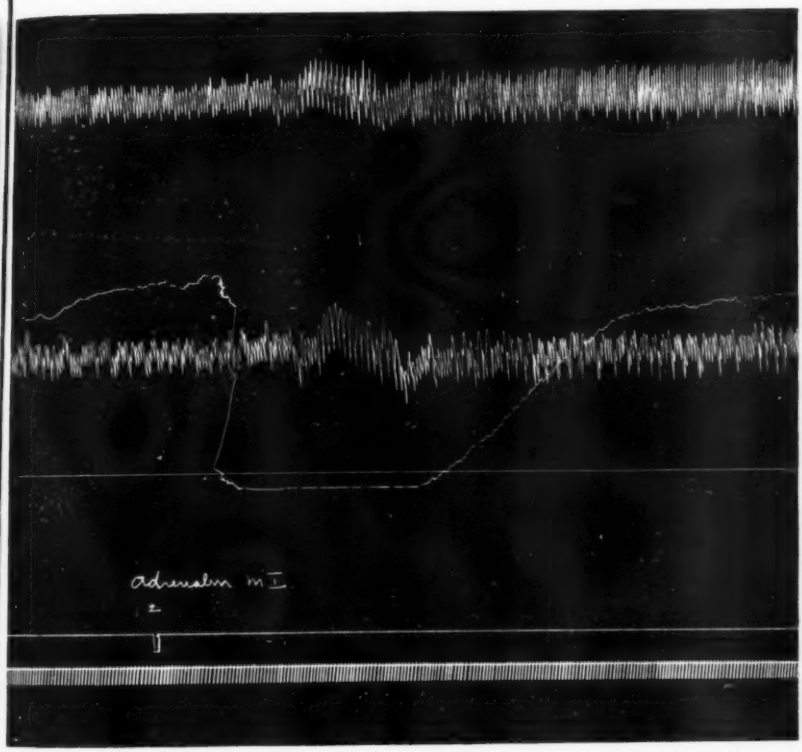
Gréhant's anesthetic. Seven full grown animals were used in this group. All of the animals were diuretic on the day of the experiment.

Followign Gréhant's anesthetic in 60 per cent strength all of the animals of this group became anuric and remained anuric throughout the experiments.

The renal vessels were responsive to the dilator effect of caffein (tracing 3).

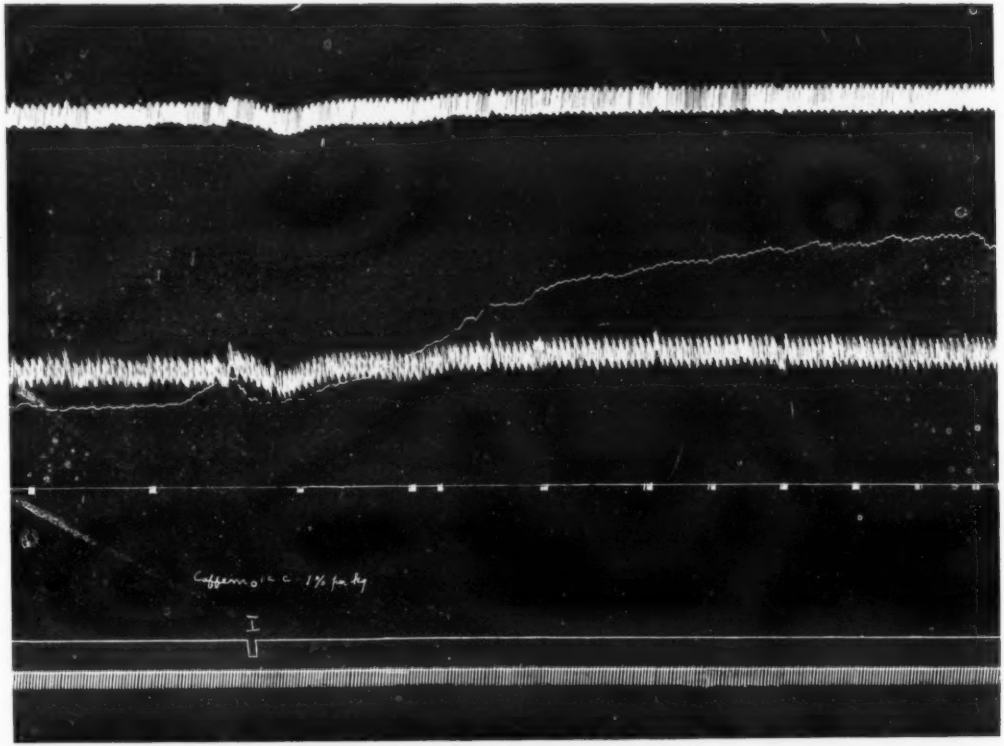
The degree of vasodilation varied between a minimum response of +17 mm. to a maximum response of +93 mm. In none of the experiments was the vasodilation associated with the establishment of a flow of urine (table 2).

In this group adrenalin induced a vasoconstriction and



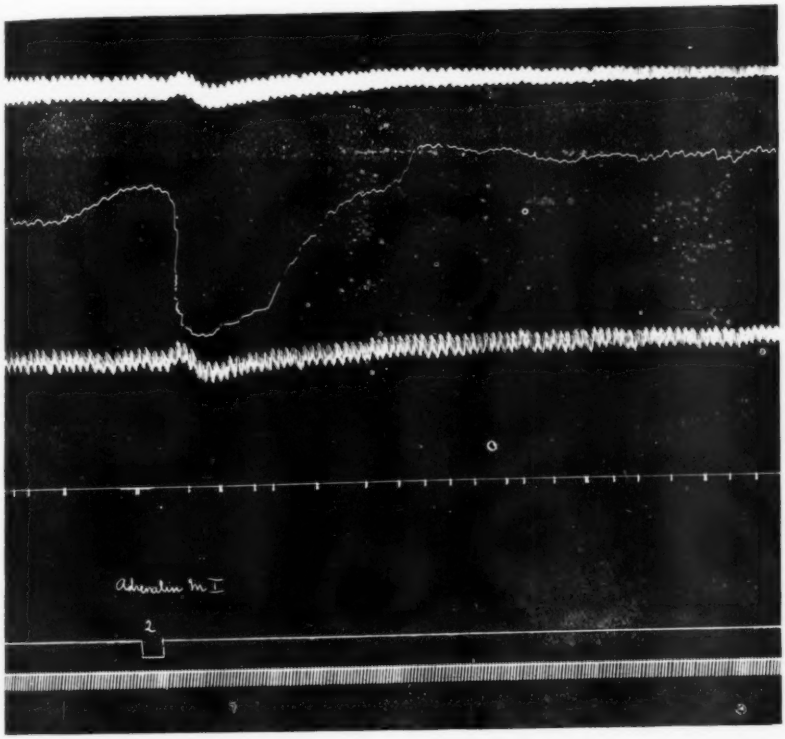
TRACING 4. EXPERIMENT 1, TABLE 2

The tracing is from the same animal as tracing 3. The tracing shows that the reneal vessels in the anuric animal are responsive to adrenalin. At the lowest point of the tracing which indicates the kidney volume, the lever of the piston recorder had reached its limit in downward excursion. The tracing shows that the renal vessels were responsive to adrenalin but does not indicate the degree of responsiveness.



TRACING 5. EXPERIMENT 1, TABLE 3

The tracing is from an animal that remained diuretic following morphine-ether as an anesthetic. Caffein induced but little effect in the heart volume or general blood pressure curve. Following caffein there was the usual dilatation of the renal vessels and a rise in kidney volume. The flow of urine was increased.



TRACING 6. EXPERIMENT 1. TABLE 3

The tracing is from the same animal as tracing 5. Following the decrease in kidney volume from adrenalin there is a transitory slacking in urine flow. The effect is comparable, though to a less extent, to the result shown in tracing 2. With the increase in kidney volume following the adrenalin constriction the flow of urine increases. The decrease in the excursions of the writing pen of the Hurthle manometer are due to a partial obstruction by a clot in the connection leading to the manometer.

fall in kidney volume varying between the extremes of —16 mm. to —72 mm. (tracing 4).

From the brief summary which has been given of the vascular response of the kidney in these different groups of animals and from a survey of the accompanying tables it will be seen that the vascular response of the anuric group of animals (Group II, table 2) to both caffein and adrenalin is comparable in its degree to the vascular response which has been obtained from these substances in the control group of animals (Groups I and III).

In the control groups, with two exceptions, a vasodilation from caffein has been accompanied by an increase in the flow of urine, while in the anuric group (Group II) a vasodilation as great or greater than the vasodilation obtained in the above mentioned groups has had no effect in establishing a flow of urine.

It would, therefore, appear that the condition of anuria is not dependent upon any lack of response on the part of the renal vessels and also that diuresis from caffein is dependent upon some mechanism in the kidney other than a responsive vascular mechanism.

THE PATHOLOGY OF THE KIDNEY IN ANIMALS NEPHRITIC FROM URANIUM WHICH FOLLOWING AN ANESTHETIC EITHER REMAIN DIURETIC OR BECOME ANURIC

When the animals which have been employed in the previously discussed experiments are classified from the standpoint of the pathological changes developing in the kidney, the animals in Groups I and III which have remained diuretic following the different anesthetics are found to present a pathological response which in general is similar; while those animals which have become anuric, Group II, show changes in the kidney of the same character but of sufficient difference in degree to separate them from the diuretic groups of animals.[2]

[2] A detailed account of the pathology of the kidney in animals either anuric or diuretic, following different anesthetics will be found in the Jour. Med. Research, xxviii, 3, 1913.

The vascular pathology of the kidney in both the diuretic and anuric animals consists primarily in an acute congestion which is most marked at the glomerulus. The glomerular capillaries are engorged with blood and fairly uniformly fill the space enclosed by the capsule. Occasionally between the capillary tufts and the capsule there has been observed a small quantity of granular material. This has never been present in such an amount as to compress the capillaries. Blood cells have not been demonstrated in this material.

The capillaries have failed to show any histological evidence of changes of a degenerative character. The interest-

FIG. 1. EXPERIMENT 3, TABLE 1

The figure shows the absence of acute swelling of the epithelium. The epithelium is not necrotic. The lumen of the tubules is not encroached upon by the epithelium. The glomerular vessels are engorged with blood and fairly uniformly fill the capsular space. The renal vessels were responsive to peripheral stimuli. The figure represents the kidney of an animal that remained diuretic following Gréhant's Anesthetic.

ing type of vacuolar degenration of the capillary walls, first described by Christian (5), has not been present in this series of animals. Neither have the more extensive structural changes been observed which have been described by Chris-

tian and O'Hare (6) as occurring in the glomeruli of rabbits, nephritic from uranium. In a later communication by O'Hare (7) the relative difficulty is shown of inducing in the dog glomerarular lesions of a degenerative character.

The point of difference which serves to separate pathologically the diuretic from the anuric animals consists in the difference in the degree and extent to which the epithelium of the kidney has become involved.

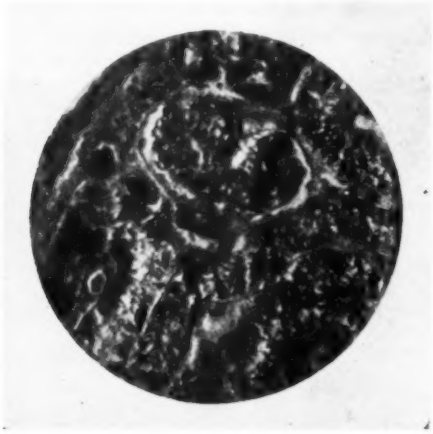


FIG. 2. EXPERIMENT 1, TABLE 2

The figure represents the kidney of an animal anuric following Gréhant's Anesthetic. The epithelium of the tubules shows extensive necrosis. The lumen of the tubules have become obliterated by the swollen epithelium. The glomerular changes are similar to those shown in Figure 1. The renal vessels were responsive to peripheral stimuli.

In those animals which are found in Groups I and III that remain diuretic following an anesthetic the degree of epithelial damage is slight (figs. 1 and 3).

The epithelium of the convoluted tubules is histologically well preserved. Both the cytoplasm and nuclei of these cells stain well. The cells either show no swelling or the degree of

swelling is slight. Vacuolation of the cytoplasm which is such a constant and marked feature in the epithelium of the anuric group is rarely present.

Henle's loop tubules, and especially the ascending limb of Henle's loop contains a small amount of fat.

The epithelial involvement in the diuretic animals (Groups I and III) is most marked in those animals which either have a comparatively slight flow of urine or that during the course of the experiment become anuric (experiment 6, Group I, table 1; experiment 6, Group III, table 3). In such animals the epithelium of the convoluted tubules shows

FIG. 3

The figure represents the kidney of an animal which remained dieuretic following morphine-ether. The epithelium is not necrotic and shows only a slight degree of swelling. The histological changes are comparable to those changes seen in Figure 1.

both swelling and vacuolation, while the epithelium of tubules deep in the cortex occasionally show areas of necrosis. Such areas are small and limited to a few tubules.

In the anuric group of animals (Group II) the epithelium becomes actually swollen and vacuolated and the swollen

cells either greatly encroach upon or occlude the lumen of the tubules. The vacuolation usually first appears in the zone just around the nucleus and later not infrequently takes the place of the nucleus. The vacuoles are not fatty in nature. These are the initial changes. The epithelium of the tubules deep in the cortex and of the convoluted tubules undergoes a rapid necrosis. The swelling and necrosis may be of a most severe grade (fig. 2), and involve all of the tubules of the labyrinth excepting the junctional and collecting tubules. These tubules are not usually involved in the necrotic process.

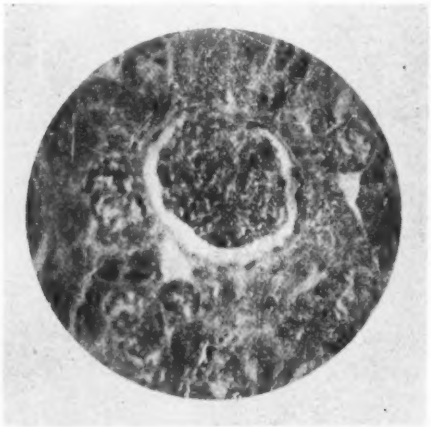


FIG. 4

Figure 4 represents the kidney of an animal nephritic from uranium nitrate. The nephrotoxic substance was given in the usual dose of 6.7 mgs. on two successive days. The kidney was removed under light ether anesthesia. The animal was freely diuretic. The epithelium is not necrotic. The lumen of the tubules have not been encroached upon by any marked swelling of the epithelium.

The above mentioned changes are remarkable not only on account of their wide spread nature and severity, but on account of the rapidity with which they develop.

The tubules of the loop of Henle contain large amounts

of fat. The fat, when stained by Herxheimer's Scharlach R method, appears in the form of coarse granules or large masses.

In Groups I and III there are animals which after an initial period of diuresis become anuric (experiment 6, Group I, table 1 and experiment 6, Group III, table 3). These animals have shown a vascular response to both caffein and adrenalin, which in degree is comparable to the vascular response of animals in the same groups that remained diuretic. They differ, however, from the diuretic members of the group in that the degree of epithelial involvement of the

FIG. 5

Figure 5 represents the remaining kidney of the same animal after the animal had been subjected to Gréhant's Anesthetic for one hour. The epithelium is severely swollen and shows an extensive necrosis. As a result of these changes the lumen of the tubules has become obliterated. The animal was completely anuric.

Figure 4 should be compared with figures 1 and 3, and figure 5 with figure 2.

kidney is much more pronounced than it is in those members remaining diuretic.

It would appear, therefore, that the gradual development

of an anuria is more dependent upon the extent to which the epithelial element of the kidney becomes damaged than upon any lack of response upon the part of the renal vessels.

This observation has been confirmed in the following way. Six animals have been rendered nephritic by the usual amount of uranium. One kidney which serves as a control (fig. 4) has been removed under very light ether anesthesia. The animals were then given Gréhant's anesthetic in the usual amount. When the flow of urine had been greatly reduced, or an anuria had developed, the remaining kidney was removed and studied histologically in comparison with the control kidney (fig. 5).

By employing such a method it was found that associated with any decided and continued reduction in the flow of urine which was not increased by a rise in general blood pressure or by a vasodilation of the renal vessels from caffein, the epithelial element of the kidney showed the same type of degenerative change which had been found in the group of animals that were anuric from the commencement of the experiment (Group II, table 2) and the same type of changes which had developed in those animals of the control groups (Groups I and III) that late in the experiment became anuric.

In conclusion; the anuric and diuretic groups of animals show no changes in the vascular element of the kidney which will serve to differentiate them histologically. The essential pathological difference between the two groups lies in the difference in the degree and extent of the involvement of the epithelial element of the kidney.

The epithelial damage in the diuretic animals is slight; in the anuric group it is extensive.

DISCUSSION

It has been shown in the animals which have been used in the present investigation that the renal vessels remain responsive to stimuli which either lead to their dilatation with an increase in kidney volume or to their constriction with a decrease in kidney volume.

The degree of this response in the animals of the different groups, and in the animals of the same group varies. As a result of these variations it is difficult to say that the animals in one group are more responsive to these stimuli that are animals in another group. It is, however, clearly demonstrated by the control groups of nephritic animals (Groups I and III) that following a vasodilation from caffein which may be as low as +32 to +37 mm. an increase in the output of urine takes place; whereas in the anuric group of animals (Group II) with vessels responsive to the same stimulus, and giving a vasodilation which may be much greater than that recorded above, +63 and +91 mm., no flow of urine takes place.

The experiments which have been conducted in this investigation, in addition to the experiments which have been referred to in former investigations (1 and 2), would indicate that the vascular mechanism of the kidney in an animal nephritic from uranium and anuric following an anesthetic, is as responsive to caffein and adrenalin as is the vascular mechanism of the kidney of an animal nephritic from uranium which following an anesthetic remains diuretic.

The conclusion seems clear that the acutely developing anurias in uranium nephritis which may follow the use of different anesthetics are not dependent upon any loss in irritability on the part of the renal vessels.

In the investigation by Pearce, Hill and Eisenbrey (4) which has been previously referred to, the authors have pointed out the effect of an anesthetic in inducing an anuria and have also shown that the ability of the renal vessels to dilate is retained. The phenomenon of vasodilation with little or no diuresis they attribute to an impermeability of the glomerulus which follows the anesthetic.

In the present investigation the changes in the kidney which have been constantly associated with the development of a complete anuria, and the changes which develop in the kidneys of those animals that at the commencement of the experiment are diuretic but that later become anuric, have

consisted in degenerative changes in the epithelium of the tubules and principally in the epithelium of the convoluted tubules. These degenerative changes which may, or may not be associated with an acute swelling of the epithelium, terminate in necrosis.

CONCLUSIONS

1. When caffein is given to an animal nephritic from uranium with an epithelial element histologically intact, following a rise in kidney volume from the vasodilation induced by the caffein there is an increase in the flow of urine.

2. When however, caffein is given to an animal nephritic from uranium with an epithelial element which is in various stages of necrosis, there is no change in the rate of urine flow even though the vascular response from the caffein may be as great as or greater than the vascular response in the animals in which the caffein was of diuretic value.

3. From the observations which have been made in the present investigation it would appear that the functional capacity of the kidney nephritic from uranium is more dependent upon an intact epithelial element than it is upon a responsive vascular mechanism.

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NOTES ON NEW AND RARE SPECIES OF FUNGI FOUND AT ASHEVILLE, N. C.

BY H. C. BEARDSLEE

The State of North Carolina seems to be very rich in its fungous flora. The great variety of conditions found within our borders give ample room for a large number of species of these interesting plants, many of which appear to be rare in the United States, while not a few seem to be new to science.

The following notes have been selected from the writer's accumulation during the past twelve years as of possible interest to those in our state who are interested in these difficult and puzzling plants. All of the species discussed have been found near Asheville, and will doubtless be found quite generally in at least the western part of the state.

Lepiota floccosa sp. nov.

Pileus 2-5 cm. broad, at first campanulate, then expanded and obtusely umbonate, thickly covered with a soft, smooth, appressed tomentum, which is brown and at first continuous, then broken into appressed scales with the lighter context showing between. Margin thin, extending beyond the lamallae in a soft cottony margin.

Lamellae pure white, crowded, narrow, free.

Stipe pure white, thickly covered with white fibers which are at first attached to the margin of the pileus, and form a thick annular zone toward its summit.

Spores broadly elliptic 6-8 by 3-4 mc.

This species has been observed for several years. In appearance it is much like *L. clypeolaria,* but the spores are absolutely different. It has some of the characteristics of *L. acutesquamosa* Weim., but is amply distinct from it. It has the pileus always smooth and never shows the slightest trace of the acute scales which mark this latter species. The thick mass of white fibers which clothe the stipe is very characteristic and will at once distinguish it. Bresadola, whose

thorough knowledge of the Agarics is well known, says it is unknown in Europe. I find it each year in deep woods.

Lepiota parva sp. nov.

Pileus 6-12 mm. broad, thin, campanulate, then expanded and nearly plane with a rounded umbo, delicately tomentose, striate on the margin.

Lamellae pure white, rather distant from the stipe, crowded, very narrow.

Stipe slender, pure white, glabrous, 1-3 cm. long.

Annulus persistent, rather small. Spores 5-6 by 3-4 mc.

Growing in moss and on bare ground in woods.

This dainty species is closest to *L. parviannulata* of Europe. I find it frequently in colonies. It is a very delicate and distinct species.

Lepiota caerulea sp. nov.

Pileus 10-15 mm. broad, campanulate, then expanded and umbonate, blue gray, with the umbo darker, marked with dark, appressed fibrils, striate on the margin.

Lamellae flesh color, ventricose, free, thin, crowded.

Stipe slender, 2-3 cm. long, glabrous, white.

Spores ovate, apiculate 4-5 by 2-3 mc.

The peculiar blue-gray color of the pileus, with its small size and minute spores mark this species. It is not common but is found every year.

Two other species of Lepiota occur at Asheville which are possibly worthy of note, are withheld for the present. One which I call *L. brunnea* in my notes is much like Peck's *L. fuscosquamosa* but is uniformly only a fraction of its size. I find it from 5-8 mm. broad while Pecks's species is 2-5 cm. broad. This seems too great a difference to be reconciled, but the fact that the spores are about the same in the two species makes me hesitate.

Cortinarius robustus sp. nov.

Pileus as much as 14 cm. broad, very solid and firm, dull date brown, the paler margin thinner and inflexed, becoming expanded with maturity, viscid when moist, flesh firm, blue when moist, becoming white in drying.

Gills at first violaceous, then pallid, finally cinnamon, the violaceous tint persisting under the inflexed margin, adnate, irregular on the margin.

Stipe solid, firm, rather short, slightly violaceous, fibrillose to the point where the incurved pileus touches it, pubescent above that.

Spores 9-10 mc. long.

This is the largest and firmest species of Cortinarius that I find at Asheville. It belongs to Phlegmacium but seems distinct. I find it in large colonies under oaks. The stipe is only slightly bulbous in my specimens and never marginate.

The Carolina Cortinarii are quite numerous and very perplexing. Many of Peck's New York species occur in our mountains, along with some species which appear to be rare farther north. *Cortinarius balteatus,* of which I find no record in the United States, occurs with us occasionally, and is one of our finest species.

Boletus carolinensis sp. nov.

Pileus bright golden yellow, 5-8 cm. broad, viscid, staining the hands yellow, hemispherical, then expanded, and sometimes depressed at the center, margin thin, at first incurved.

Tubes at first white or nearly so, then yellow flesh color, mouths round, thickly covered with yellow glandular drops, which give them a yellow color.

Stipe colored like the pileus, but a little lighter, viscid, pruinose under a lens, often tapering downward, sometimes becoming hollow.

Spores ochraceous tan, 10-12 mc. long, appearing bright yellow under the microscope.

In lawns under oaks. Not common.

This is our most brilliant yellow species. I know no species which is very close to it. It is unusually viscid and the hands are stained in handling it. The tubes appear stuffed when young. The flesh is firm and white. The spore color is close to Ridgway's Mars yellow.

Volvaria cinerea sp. nov.

Pileus 1-2 cm. broad, gray or bluish gray, soon plane, with a small rounded umbo, clothed with long, dark, appressed fibrils, striate on the margin.

Gills rounded behind, remote from the stipe, white, then flesh color.

Stipe white, solid, fibrillose.

Volva dark colored, splitting into three or four divisions.

Spores 5-6 mc. long, broadly elliptic.

Growing on rotting logs of deciduous woods.

Our species of Volvaria are few in number and are rare. So far I have found but three species at Asheville. Each year I find *V. parvula* Weim. growing in flower beds under weeds. This is a very dainty species scarcely 1 cm. broad, pure white, and umbonate.

The third species is *V. pubescentipes* Pk. which is also *V. hypopitya* Fr. This is found usually growing on old leaves and is pure white with its pileus usually 4-6 mm. broad.

The following species occur at Asheville, though I find no record of their detection in other parts of the United States:

Tricholoma saponacea Fr.

This is occasionally found in the fall in oak woods. It has a curious soapy odor as it dries and the flesh and lamellae tend to turn red when injured. Bresadola has seen both my specimens and photographs and positively identifies them as this species.

Inocybe corydalina Quel.

This is one of our most interesting species of Inocybe. The pileus is white and of good size (3-7 cm. broad). It becomes more or less brown with age. The gills are pure white, then cinnamon, and the spores smooth. The flesh is white and becomes red when cut, especially in young plants. It has a peculiar odor which is very pronounced. Those to whom I have submitted it here compare the odor to that of Sandal Wood. This species seems to be closely related to *I. pyriodora* and as a matter of fact my plants seem to have part of the characters ascribed to both species, the reddening of the flesh is more suggestive of *I. pyriodora* than of *I. corydalina* but the odor is not at all that of fruit. Bresadola has seen and verified my specimens.

Hygrophorus calyptraeformis B. and Br.

Of all our Hygrophori this is the most attractive species. I find it in only one station. It is a beautiful rose pink in color and the thin pileus is acutely umbonate and split into recurved lobes. It is exactly in accord with Cook's figure. It is so striking that it must be rare as I find no record of its occurrence.

Two species of Crepidotus, *C. calolepis* Fr. and *C. mollis* Fr., are also not rare at Asheville. These are usually referred to *C. fulvotomentosus* Pk. and *C. haerens* Pk. The original description of *C. calolepis* does not well fit our plant, which accounts for the failure to recognize it.

It may be said, however, that the discrepancies are just as marked in the case of the Swedish plant. I found in 1905 abundant material of Frie's species in one of his old collecting grounds in Sweden and found it identical with our own plant. The same may be said of *C. mollis*. This species is viscid and has a peculiar gelatinous context, and a separable cuticle. Both our plant and those found in Sweden have these peculiarities and seem not to be different in any essential character. One who has seen both growing will have little doubt that our plant is the same as Fries' species.

ASHEVILLE, N. C.

THE INFLUENCE OF RADIUM RAYS ON GERM CELLS AND EMBRYONIC TISSUES*

BY W. C. GEORGE

Since 1910 there have been some valuable contributions to our knowledge of the influence that radium rays exert on animal tissues. Perhaps the most important of these is Oskar Hertwig's paper entitled *Radiumkrankheit Tierischer Keimzellen,* which I have had occasion to read in the course of some of my own investigations in regard to the effects of various changes in the environment on the development of embryos. The results recorded in this paper together with some later results obtained by Oskar Hertwig, his son, Gunther Hertwig, and others, will constitute the basis of my remarks this evening, in which I shall attempt to give you a conception of the present status of our understanding of the biological effects of radio-activity.

But before proceeding with a consideration of the later discoveries, it would probably be of value to review the discoveries made before 1910. Soon after the discovery of radium in 1908 by Mme. Curie, biologists began to study the influence that Rontgen and radium rays exercise upon animal cells that they strike. The experimenters who studied the influence upon animal cells may be divided into two groups. Those of the first group examined the effect of radiations upon the male and female sex cells. To this group belong Bohn, Perthes, Schwarz, Schaper, Levy, Bardeen, and others. All of these workers came to the conclusion that radium rays exercise a retarding and injurious effect upon the embryonic processes. Schwarz and Schaper attempted to explain the effect of radium rays by the decomposition of lecithin in the living cell. The American investigator, Bardeen, working with amphibian eggs, found that the period of greatest susceptibility is the period during which there is the most rapid production of nuclear material.

*Read before the Medical Society of the University of North Carolina, October 16, 1915.

The investigators in the second group studied the effect of the radium rays upon the different tissues of the more or less advanced organism. Seldin, Birch-Hirschfeld, Werner, Heinecke and Thies, Ragaud and Dubreuil, Bergonié and Tribondeau, Aubertin, Delamare and Beaujord, Guyot, Schumann, Lidenborn, and London are some of the workers in this field. They found that all tissues are sensitive to radium rays, but to a varying degree. In general cells appear to be sensitive to radium according as they have the character of germ cells and have the tendency to increase through rapid cell division. Two kinds of tissues are particularly affected: (1) male and female gonads with the eggs and sperm; (2) blood and lymph with the related spleen, lymph glands, etc. The chromatin of the cell nucleus is affected injuriously and finally the nucleus will be destroyed. As a result of the discoveries of the workers in this field Rontgen and radium rays have found an application in the treatment of rapidly growing structures, such as cancers and tumors.

As previously stated, the study of the action of radium has been pushed for the past few years by Oskar Hertwig, director of the Anatomical-Biological Institute of the University of Berlin. In 1909 he began and has since continued a series of experiments on the influence of radium rays on the development of amphibian embryos. He ran two series of experiments. In his A-series fertilized frog eggs were irradiated for various lengths of time, from five minutes to four hours. Only those eggs radiated for a short time (5-15 minutes) developed beyond the very early stages. Those subjected to a longer or stronger radiation did not pass beyond the blastula stage, where they died.

The B-series consisted of experiments in which sound eggs were fertilized with sperm radiated for various lengths of time from five minutes to twelve hours. He obtained a great variety of abnormalities which have considerable bearing on general embryological theories. We shall not consider that side of his results, however, but shall confine ourselves

to the biological effects of radio-activity. Hertwig found that the effects of the radium depend upon the strength and duration of the radiation. The effect of five minutes radiation of the sperm was clearly recognizable in the resulting embryo. Radiation of longer than five minutes always has a worse result until a certain low point is reached. This falls with increased radiation up to one hour. From here on the developmental curve begins to rise with increased radiation. Six to twelve hours radiation of the sperm produces astonishingly pretty normal embryos.

What action have the radium rays upon the sex cells to account for the results? Schwarz's and Schaper's Lecithin Hypothesis, i. e., that the injurious effect is due to the decomposition of lecithin, is insufficient. The lecithin hypothesis has not been established by chemical analysis, and it does not explain the results of fertilizing sound eggs with sperm radiated different lengths of time. Sperm radiated for five minutes cause very abnormal development, and in this case a very small amount of destructive products of lecithin would be added to the relatively immense mass of the egg.

Hertwig's theory is that by radiation with radium the nature of the germ cells as living organisms is altered (made pathological). In eggs fertilized with radiated sperm we have a fusion of a sound and a pathological germ, and the sick germ, the chromatin being chiefly important, acts as a *contagium vivum* (an infectious *bacillus*). It causes abnormal development because in fertilization the pathological male chromatin fuses with the egg nucleus and in all future mitoses this pathological chromatin increases and is distributed to all the cells. In eggs radiated after fertilization we get more abnormal embryos because both maternal and paternal chromatin is made radium sick. That the protoplasm does not suffer so much injury as the chromatin seems to be shown by the fact that the sperm loses its motility only after very long and intense radiation.

Why, after passing a certain point, does increased radiation result in improvement in development? This is explained on the assumption that the degree of abnormality depends not only on the degree of injury to the chromatin but also upon its power to increase and divide so that all cells will be affected by the radium sick chromatin. After passing a certain point the power of the paternal chromatin to increase and divide becomes less or becomes wholly lacking. If the chromatin loses its power to increase after prolonged radiation then a real fertilization in the sense of a fusion of equal maternal and paternal germs no longer occurs, and the development of the egg assumes the character of parthenogensis. Fertilization, where the power of the chromatin to increase is wholly lost, is only a developmental stimulus.

That the eggs of vertebrates generally may have the power to develop parthenogenetically seems to be shown by Bataillon's experiments on the frog eggs and by Lacaillon's discovery that bird eggs sometimes start development naturally without having been fertilized. Bataillon caused frog eggs to develop without fertilization by pricking them with a fine platinum needle. His experiments have been repeated by Dr. Bancroft, of the Rockefeller Institute, in our own laboratory, and also by MacClendon of this country, by Dehorne and Henneguy of France, by Brachet and Herlant of Belgium, and by Levy of Germany. And so it is now a well established fact that the frog egg has the power to develop parthenogenetically. From some of the later investigations, however, it now appears that for the frog egg to develop beyond the very first stages, something more than a puncture is necessary. A blood or lymph cell, or at any rate some solid element derived from the blood or lymph, must be introduced into the egg cytoplasm. This calls to mind that an American, Guyer, before Bataillon's discovery, reported that he had succeeded in fertilizing frog eggs with blood and lymph. Guyer in interpreting his results, seems just to have missed the real fact that the egg itself under the influence of a stimulating agency starts to develop.

It has also been shown that the chromatin of a penetrating sperm may be eliminated from the developmental processes. Both Boveri and Teichmann have fertilized eggs of Echinus with sperm treated with potash solution, and though the sperm entered the egg and intiated development, the sperm nucleus did not fuse with the egg nucleus. Loeb and later Kupelwieser caused sea-urchin eggs to develop by adding sperm of Mytilus (a salt water mussel). The sperm entered the egg but the head of the sperm with its chromatin took no true part in the development.

Since first putting forth his theory that it is the chromatin that is chiefly injured by treatment with radium, the evidence in favor of it has been added to by further experiments by Hertwig, by his son Gunther Hertwig, and by Opperman. Oskar Hertwig has found in the larvae of Triton obtained from sound eggs fertilized with irradiated sperm, that the nuclei of the body cells have only half or the reduced number of chromosomes, the male chromosome complex having failed to take its part in development. Gunther Hertwig has shown that by intensive radiation of several hours duration sperm threads of the sea-urchin are so affected that though they are able to penetrate the egg and stimulate development, they lose their ability to form normal chromosomes and thus are eliminated from development. He also found that in frog eggs treated with radium and fertilized with normal sperm, the injury increases with the duration of the radiation up to a maximum and from there on decreases again as the radiation is prolonged—as his father found for sound eggs fertilized wits radiated sperm. Only the radiated nuclei show the effects of the treatment. In the frog then development is possible with only a haploid nucleus, i. e., only the half of the nucleus derived from one of the parents. Where the injury is severe to either the egg or the sperm nucleus, the other is able to carry on the development, and in fact there is less deviation from the normal course of development than in the case where both nuclei are injured only slightly. All of this evidence seems

to bear out Hertwig's conclusion that it is the chromatin of the cell that is chiefly injured by treatment with radium, and that when the injury is severe enough the damaged chromatin is eliminated and the egg develops parthenogenetically.

There has been some criticism of Hertwig's explanation of the action of radium on the ground that it does not go far enough back into the organization of the cell, and it is said that further explanation must ultimately be chemical in nature. Packard, and Richards who recently published an interesting article in *Science* on the biological effect of radio-activity, have sought to explain its influence by the effect that radium has on certain intercellular enzymes; but in the present state of our knowledge of biochemistry it cannot be said that we know anything about chemical processes that go on within the egg which can be regarded as the causes of differentiation, though further information of this nature is greatly to be desired.

CHAPEL HILL, N. C.

WINTER GRASSES OF CHAPEL HILL

BY W. C. COKER

PERENNIAL RYE GRASS (*Lolium perenne*).
ITALIAN RYE GRASS (*Lolium multiflorum=L. italicum*).

These two grasses can scarcely be distinguished from each other except in flower, and are so alike that we may treat them as one. They are short lived perennials in this state.

They may be distinguished by their deep green, shining leaves and bright-red or purplish-red leaf bases. They most resemble blue grass when young, but blue grass is not shining and lacks the red base.

Wherever lawn mixtures have been sown these grasses usually escape to the roadsides, walks, open places, and gardens, and there form one of the most conspicuous elements in our winter grass growth. They do not form a part of the old established lawns or pastures.

Rye grass is one of the constituents of most lawn mixtures, and we notice that in lawns here it is one of the three or four species that survive the first summer to any extent. It is also obvious that usually not one-tenth of the original stand goes through the summer. Of this remaining one-tenth the rye grass often forms almost one-half. The other half is mostly red top, sheep fescue or red fescue, and in shaded places blue grass.

The rye grasses germinate quickly and grow off rapidly and thus serve to give a green effect the first winter before the slower grasses have made much show. They begin to die out the first summer, and after two or three years are usually quite gone.

LOW SPEAR GRASS (*Poa annua*).

This odd little grass is what is called a winter annual, sprouting in fall and flourishing through the cold weather, then dying out completely at the beginning of warm weather. The exact time of its sprouting and dying depends entirely

on the weather. In the spring of 1914, which was quite dry, it disappeared before the first of June, reappearing again in September. In damp, cold springs it will live well into June. It is peculiar in its requirements, seeming to prefer hard, bare, open places and it does not mind being trampled by man or animals. It occurs on walks and road margins, in waste places and to some extent in lawns, as on the campus. The best turf of *Poa annua* in Chapel Hill is in front of the poultry houses and west of the cow barn on Glenn Burnie Farm. The turf it forms is exceedingly close and fine, and the growth is so short that it requires little or no mowing. If it would only last through the summer, it would make an ideal lawn. As it is, however, it is rarely planted, and the seed are hard to get in the trade. It is used to some extent to help the winter sod of putting greens, and would be fine in its season for terraces, grassed walks, courts, etc.

SWEET VERNAL GRASS (*Anthoxanthum odoratum*).

This is a strongly bunched, early maturing grass that is fond of cold weather and does most of its growing in winter and spring. By the middle of March it is 4-6 inches high, even in our colder winters, and it forms most of the first spring cutting in more shaded parts of the campus and in many of our shaded lawns that are not mowed often. In more open lawns and those that are mowed frequently it is scarce, apparently not liking the sun or the lawn mower. On account of its densely tufted habit it is not a desirable lawn grass, but for groves and parks and meadows where the mowing is not frequent or close it is an agreeable constitutent on account of its very pleasant vanilla odor when cut and also for its ability to stand much shade and make a green show in winter. We recommend it as one of the ingredients for sowing all shaded places not closely mowed.

KENTUCKY BLUE GRASS (*Poa pratensis*).

Blue grass is the best lawn grass to be had where it can be made to flourish. It does not like hot dry weather or poor soil, and we have to treat it with special care to entice it to

grow in our southern states. In this latitude its principal requirement is a rich soil, and next is shade and water in dry weather. It forms a deep green, dense, and permanent turf and is worth taking trouble to secure (see article, *The Lawn Problem in the South,* in this issue for treatment of blue grass). In Chapel Hill blue grass occurs spontaneously to a considerable extent in good soil by walks, roads, in orchards, open places, back yards, shaded lawns, etc. It makes very early growth in spring and by March it probably furnishes the greater part of the green grass growth that has appeared. In all well shaded lawns, such as in the Alexander Place, the McRae Place, the old Martin Place, etc., the blue grass is the principal grass and maintains itself without attention, but unless well shaded it must be watered in dry hot weather or it will disappear. Unless heavily shaded a very fertile soil is of prime importance with blue grass.

ORCHARD GRASS (*Dactylis glomerata*).

This large grass makes tall green tufts that are conspicuous by the last of March. It much prefers shaded places and is rather common in fertile soil by paths and roads and in waste places. It forms most of the growth in the low depression west of the old Mangum Place. It is not suited for lawn grass on account of the large separate tufts it makes, but is valuable for hay or grazing in open or shaded places. It was one of the three grasses sown on Glenn Burnie hills in the fall of 1912 and it has now become well established there and forms most of the forage. It hardly made any show the first summer as it is of slow growth at first.

TALL MEADOW OAT GRASS (*Arrhenatherum elatius*).

This was planted by me as one of the four constituents on my hillside hay fields at Glenn Burnie Farm. The others were Italian rye grass, orchard grass and red clover. The ground was gravelly clay and not very rich. The oat grass did not take very well and formed only a small part of the first summer cutting (1913). The Rye grass did much better and formed the bulk of the cutting. The orchard grass hardly showed up at all the first summer, but has since been

the principal ingredient of the hay. Clover did well in richest places only. The oat grass has now (Sept., 1915) almost disappeared from these fields, except on terraces and borders. It is not a persistent grass in this latitude and is not found on roadsides or other waste places.

CHESS OR CHEAT (*Bromus secalinus*).

This is a vigorous spring grass that would make good grazing but as it is no better than a number of others for this purpose and as it is a bad weed in grain crops it is now almost never planted. It is an annual, but reseeds itself persistently. As it looks remarkably like oats or wheat until headed and has the same growing season as these it is necessary to rotate the grain fields when it gets established. Farmers long believed and many still believe that cheat can turn to wheat or oats and *vice versa*. It is very plentiful along borders on Glenn Burnie farm, and is a bad weed among the oat fields on Rocky Ridge Farm.

RAT'S-TAIL FESCUE GRASS (*Festuca myuros*).

This is a delicate grass with round, thread-like leaves that makes up a large part of the roadside and embankment growth on Glenn Burnie Farm and in waste places generally. As it is an annual and dies early in summer it would not be of much use as a lawn grass except for Bermuda lawns, and there are others better for this purpose.

RED TOP (*Agrostis alba*).

This is one of the principal forage and lawn grasses of the northern states and is undoubtedly an ingredient of all or nearly all the lawn mixtures we get from seedsmen. In this latitude, however, it is not able to maintain itself for many years in competition with other vegetation and while helping to fill in the lawn for two or three years, it does not last much longer. It is a spreading and procumbent grass that is easily recognized by its glaucous green color with a tint of purple in all parts. In Chapel Hill it can be detected in most recently sowed lawns, and in the arboretum it seems to be maintaining itself better than usual, due probably to the moist nature of the soil. In the paths here young seedlings of red

top and blue grass appear in abundance every spring. For low grounds in this section it is a valuable forage grass and persists much better than in uplands.

CREEPING BENT GRASS (*Agrostis stolonifera*).

This is probably only a variety of red top, but the two have a very different appearance here. It delights in damp shaded soil and makes a thick fine carpet in such places. It is frequently an ingredient of lawn mixtures, but is good only for a short time except in the wettest places. In Chapel Hill it has formed a fine and permanent turf on the northwest corner of the arboretum on the north side of the row of hydrangeas.

SHEEP FESCUE (*Festuca ovina*).

This is a very hardy perennial grass that is very useful for dry sandy and rocky soil where little else will grow, and as our southern lawns are usually subjected to rather rough treatment it is well to include it in the mixtures that we sow. On account of its tufted habit it is not ideal for lawns, but the tufts are not so coarse as those of orchard grass or sweet vernal grass and it is far more hardy than either. The leaves are slender and thread-like and vary much in color, from bright green to a much lighter glaucous green. If lawn mixtures containing sheep fescue are sown in poor dry soil the fescue will be about all that is left after the first summer. This can be well seen on the terraces by the Chemical building and Davie Hall as well as the mounds around trees near the Alumni Building. It was about the only perennial grass growing spontaneously in the poor gravelly soil at The Rocks before the place was fertilized and sowed with other grasses. It is of very little use as an agricultural grass in this section.

A more delicate variety of sheep fescue (*var. capillata*) is rather plentiful in spots in some of our lawns, e. g., the one east of Dr. Manning's on Rosemary Street.

RED FESCUE (*Festuca rubra*).

This is much like *F. ovina* in appearance, but grows somewhat larger and is less variable in color. It is not at all

common here, but may be seen in the Episcopal Church yard where it forms the deep green densely tufted cover on the south side by the rock wall, where shaded by cedar and elms.

CAREX TEXENSIS.

This little plant is not a grass but a sedge, and it is known in North Carolina only from Chapel Hill. It is the plant that forms the lawn over most of Mrs. Kluttz's yard on the west side, and it makes one of the best lawns in Chapel Hill, winter and summer, under the peculiar conditions there existing. The soil is unusually impervious and is much too wet in ordinary seasons for the best development of grass. The sedge finds this dampness congenial and has taken permanent possession. It is also an abundant constitutent of the deeply shaded lawn at the old Holmes Place (see Torreya *11*:11. 1911, for my first record of it from N. C.).

THE CLOVERS AND MEDICS.

There are two little creeping plants of this group that form a very conspicuous part of the winter and spring green of our lawns and waste places. They are low hop clover (*Trifolium procumbens*) and black medic (*Medicago lupulina*). They look so much alike that the casual observer makes no distinction between them, calling both hop clover, but the medic may be distinguished by its smaller and somewhat brighter yellow flower heads and, most easily, by the more elongated heads of *black, exposed, kidney-shaped pods.* The hop clover has, in fruit, nearly spherical heads, with the little brownish pods inclosed in the dried up persistent flower, giving them the appearance of a small head of hops. These two plants are winter annuals, coming in fall and dying out in May or June. They form the largest part of the spring green in the less shaded places of many of our lawns. White clover (*Trifolium repens*) is of course common in lawns, pastures and open places. It is frequently included in lawn mixtures with the grasses, and in such cases makes a larger part of the winter and spring green. It is a perennial, but unless well watered is apt to die out badly in summer.

CHAPEL HILL, N. C.

THE LAWN PROBLEM IN THE SOUTH

BY W. C. COKER

A perfect lawn as understood in our northern and middle states, Great Britain, and Europe generally, is a dense, homogeneous, evergreen carpet, composed of a single species of grass. Only in rare circumstances can such an ideal be fully attained, and it cannot be even approximated without good soil, water in dry periods, and constant care against the encroachment of weeds. As we are seriously handicapped by long, hot and dry summers, the ownership of a good lawn in the South will never be easy, and will always be the evidence of intelligence and care.

The factors that are necessary to the making of a good lawn are: (1) a rich and well drained soil; (2) the right grass or grasses; (3) water; (4) care (removal of weeds, frequent mowings, top dressings, etc.). As we usually neglect all of these essential factors, it is not hard to explain our failure.

To those who are willing to give their lawns the proper start and subsequent care, we suggest the following procedure: See that the soil is well-drained and all rocks, stumps, and trash are removed, and if the surface is irregular with ridges and sinks, a drag should be used to produce a perfectly level surface, or even slope. Give the area a heavy application of stable manure in the spring, at the rate of fifty two-horse wagon loads to the acre, and turn under deeply; put on a heavy application of water-slacked lime or of ground limestone, at the rate of about three tons to the acre, and harrow repeatedly with a cutaway harrow; continue this harrowing every two or three weeks during the summer. About September 15th to the first of October add ground bone or cotton seed meal at the rate of 1,000 pounds to the acre, and harrow again, following the cutaway with a tooth harrow. After this give a finishing touch by raking by hand with a fine tooth rake. When this is done sow, at the rate of

100 pounds per acre, a mixture of equal parts of Kentucky blue grass, creeping bent grass, sheep fescue, and perennial rye grass, and cover with a compact cedar brush, or by raking again by hand. The rye grass will grow rapidly and will give a good effect the first winter before the other slower growing grasses make much show. The blue grass, if adapted to the situation, will grow stronger and denser each year, while the rye grass will pretty much all disappear after two or three years. The fescue and bent grasses are added in expectation that they will establish themselves in certain spots to which the blue grass is not adapted. Neither is so good for lawns as blue grass and where the conditions are just right for the latter the fescue and bent grasses may be omitted.

In early spring when the ground is not too wet run a roller over the lawn, and begin to use a mower as soon as the grass is high enough to cut. The rye grass will need cutting once or twice during the late fall. Look out for moles, and kill them. Water frequently during the first summer, and take out the weeds by hand. In October give another top dressing of cotton seed meal or bone meal. Look out for thin and poor spots, and sow more seed after scratching the surface with a rake, giving extra fertilization to these places. This will give the lawn a start. Its successful continuance will require an equal amount of attention and care.

In watering the lawn do not sprinkle lightly every day, but water thoroughly every four or five days. In large lawns it is a good plan to water a part every day, getting all over in four or five days. The amount of water necessary varies of course with soil, shade, and season, and must be determined by watching the grass.

The worst lawn weeds are the perennial ones, certain of which are constantly appearing even in the best kept lawns. They must be watched for, and kept out by hand. The worst through nearly all of our territory are lance-leaved plantain (*Plantago lanceolata*), smut grass (*Sporobolus indicus*), and the clovers. Locally, wild onions and nut grass are pestiferous.

The nut grass is almost ineradicable, and when it is thoroughly established one should proceed with the lawn exactly as if it were not present.

Onions, while very tenacious, can and should be removed. One way is to loosen up the bulbs with a long narrow mattock and lift each clump as it appears. It is also claimed that onions can be killed by squirting a half teaspoonful of crude carbolic acid down into the center of each clump with an oil can.

Dandelions are not the pest with us that they are in the north but they become somewhat troublesome near the northern limit of our range. They should be removed with the sharp corner of a hoe, as should also the plaintains and smut grass.

Bermuda grass as a weed is of such a nature as to warrant special remark. Bermuda is a sun-loving plant, and in shaded lawns will not cause much trouble. But in open sunny lawns in the South it is the exception when Bermuda does not enter and gain the mastery. In such a case the wise man will accept the decree of fate, and console himself with the thought that Bermuda will give a sod that for firmness, evenness, and duration cannot be surpassed in the South. Furthermore it has the exceedingly great advantage of not requiring water. It is moreover not difficult to superimpose a wintergreen lawn on the brown Bermuda by sowing in October a generous amount of perennial rye grass on the sod, adding at the same time a good application of bone meal or cotton-seed meal. The rains will beat the seeds down to a foothold, and their prompt growth will offset the approaching passage of the Bermuda to its winter brown. The rye grass, while a temporary perennial, will disappear in part during the following season, and should be sown again each fall. In open places under average conditions, we must accept this as the best solution of our lawn problem in the coastal plain region of the South. A Bermuda grass lawn is best started by sowing the chopped up runners in March.

A word finally to those who think that any kind of lawn

is too complicated or expensive an undertaking for them. If you can afford a lawn mower you will have the one thing needful to improve the appearance of your home 100 per cent. Simply get rid of the sprouts and big weeds and run the mower over whatever comes. The spontaneous summer grasses, even if mixed to some extent with weeds, will soon give you a pretty, green expanse that you will be proud of when you think of the disreputable patch of smut-grass and dog-fennel that you used to call your front yard. When you see this great improvement already made you will not be quite satisfied until you take down that old sagging fence and plant a hedge in its place. Then, as you grow in grace and in love of beauty, you will add shrubs to the corners and about the house, shape up the walks and keep them hoed, and screen the unsightly places with evergreen privets or mock orange (*Prunus carolinianus*, not osage orange, which is not evergreen). There will be joy in your heart at these transformations, and when, some day, you realize that the neighbors are trying to follow your example your full reward will appear.

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